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EVALUATION OF NEW INSECTICIDE MOLECULES AGAINST LEPIDOPTERAN PESTS IN CASTOR (*Ricinus communis* L.)

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ABSTRACT

A field experiment carried out in Dry land farm of Sri Venkateswara Agricultural college, Tirupati during kharif2013, to evaluate the efficacy of different insecticides against major insect pests of castor revealed that all the treatments were found significantly superior over untreated control in reducing pest population and capsule damage. Cumulative efficacy revealed that the lepidopteran pests viz., capsule borer (65.11%), tobacco caterpillar (83.99%) and semilooper (85.72%) were controlled by chlorfenapyr 10 SC @1.5 ml l^{-1}. Flubendiamide 480 SC @ 0.2 ml l^{-1} (59.45%), emamectin benzoate 5SG @ 0.2 g l^{-1}(55.60%), monocrotophos 36 WSC @1.6 ml l^{-1}(53.87%) and rynaxypyr 18.5 SC @ 0.3 ml l^{-1}(49.65) found to be effective on capsule borer by reducing the percent of infestation over untreated control. The highest yield was recorded with spray application of chlorfenapyr (1973.6 kg $ha^{-1)}$ followed by monocrotophos (1636.57 kg ha^{-1}). The next best yields were recorded by the treatments rynaxypyr(1592.59 kg ha^{-1}), emamectin benzoate (1527.77 kg ha^{-1}) and flubendiamide (1476 kg ha^{-1}). The yield of castor sprayed with bifenthrin (1250 kg ha^{-1}), imidacloprid (1042.13 kg ha^{-1}) and chlorpyriphos (1030 kg ha^{-1}) gave moderate yield.

KEYWORDS: Castor, Foliage Feeders and New Insecticides

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Original Article

INTRODUCTION

Castor (*Ricinus communis* L.) is an important non-edible oilseed crop and is grown especially in arid and semi arid regions. It is grown for its beans, which contain up to 48% oil, mainly used in manufacturing of paints, lubricants, soaps, hydraulic brake fluids, polymers and perfumery products. Castor crop suffers from many biotic stresses. So far, over 100 insect pests are recorded on castor and among them sucking insects and foliage feeders are of economic importance (Basappa and Lingappa, 2001).

Pesticides are the most powerful tools available for the control of pests infesting the economic produce in castor. The indiscriminate use of these insecticides has resulted in undesirable effects like development of resistance to many organochlorines and organophosphorus compounds. In order to overcome these problems there is a need to use new insecticides with novel mode of action, which are selective and effective and are safe to environment and natural enemies.

MATERIALS AND METHODS

A field experiment was conducted at Dryland farm, S. V. Agricultural College, Tirupati to evaluate the efficacy of insecticides against insect pest complex of castor. "PCH-111" a popular castor hybrid was sown in July, 2013 and followed all required agronomic practices. Insecticide treatments included in this experiment were

applied with high volume sprayer *i.e.,* foot sprayer. Two sprayings were given one at vegetative stage and other at spike development stage and the pre-treatment data was taken 1 day before spraying and post-treatment was taken at 3, 7 and 10 days after spraying. Infestation of semilooper (*Achaea janata)* was assessed by recording the number of larva plant^{-1} on the five randomly selected plants in each plot. Infestation of tobacco caterpillar (*Spodoptera litura*) was assessed by recording number of larvae plant^{-1} on the five randomly selected plants in each plot. Infestation of shoot and capsule borer (*Conogethes punctiferalis* Guen.) was assessed by recording the number of total and affected capsules on each of the five randomly selected plants treatment^{-1} and Per cent infestation of capsules infestation of capsules for each plant was calculated by using formula

$$= \frac{\text{No. of infested capsules}}{\text{Total No. of capsules}} \times 100$$

Statistical Analysis

Efficacy of treatments with reference to infestation in different treatments were calculated by using formula

$$\text{Per cent efficacy of treatments} = \frac{\text{Infestation \% in untreated check} - \text{infestation\% in treatment}}{\text{Infestation \% in untreated check}}$$

The per cent values were transformed in to angular values which were subjected to statistical analysis **(SAS 9.3 Version)** to observe the effect of the treatments on different insect pests of castor.

RESULTS AND DISCUSSIONS

Per cent reduction over untreated control in each spraying and cumulative reduction of major insect pests due to all the 2 sprayings were calculated and the results are presented in the tables.

AFTER FIRST SPRAYING

Tobacco Caterpillar (*Spodoptera litura*)

Three Days after Spraying

Among all the treatments chlorfenapyr (66.45%) was found to be the superior treatment against tobacco caterpillar followed by rynaxypyr (64.07%). The next best treatments were emamectin benzoate (56.93%), flubendiamide (54.33%), chlorpyriphos (51.94%) and bifenthrin (51.08%). The other treatments novaluron (49.57%) and difenthiuron (42.42%) found to be moderately effective. The treatments dimethoate (37.66%) and monochrotophos (32.68%) were found to be less effective and on par with each other. The least (27.92%) % reduction of *S. litura* over untreated control was recorded by imidacloprid.

Five days after Spraying

Five days after spraying chlorfenapyr recorded 85.78 % of reduction of *S. litura* over control by bringing down the larval population over rest of the treatments. Rynaxypyr (76.08%) and emamectin benzoate (74.35%) were found to be the next best treatments. The other treatments chlorpyriphos (66.59%), flubendiamide (61.85%), novaluron (59.91%), bifenthrin (59.27%) and diafenthiuron (57.11%) were found to be moderately effective and on par with each other. The lower per cent reduction of *S.litura* over untreated control was recorded by dimethoate (49.78%), monocrotophos (42.67%) and imidacloprid (42.67%).

Seven Days after Spraying

The efficacy of the treatment chlorfenapyr was found to be 100% in reducing the larval population of *S.litura*. The next effective treatments were rynaxypyr (90.60%), emamectin benzoate (88.25%) and flubendiamide (85.90%). The other treatments bifenthrin (76.28%), chlorpyriphos (73.93%), novaluron (69.23%) and diafenthiuron (64.53%) were found to be moderately effective. The treatments dimethoate(57.48%), monocrotophos (54.91%) and imidacloprid (52.56%) recorded less % of reduction over untreated control (Table 1).

Semilooper *(Achaea janata)*

Three Days after Spraying

Among all the treatments chlorfenapyr (75.20%) followed by emamectin benzoate (70.93%) was found to be the superior in reducing the semilooper. Among the other treatments the best treatments observed were chlorpyriphos (65.45%), rynaxypyr (64.02%), flubendiamide (59.55%) and bifenthrin (59.25%). The treatments novaluron (57.11%), diafenthiuron (54.88%) were found to be moderately effective. The lower per cent of reduction of semilooper over untreated control was 36.78, 30.08 and 25.61 which were recorded by imidacloprid, monocrotophos and dimethoate, respectively.

Five Days after Spraying

Chlorfenapyr and rynaxypyr were significantly superior (85.22%) in bringing down the semilooper population over rest of the treatments followed by emamectin benzoate (82.19%). Among the other treatments the best treatments observed were chlorpyriphos (75.30%), flubendiamide (71.05%), diafenthiuron (70.85%), novaluron (70.04%) and bifenthrin (66.40%). The treatments monocrotophos (43.92%), imidacloprid (41.70%) and dimethoate (39.47%) were found to be less effective against semilooper.

Seven Days after Spraying

Among all the treatments chlorfenapyr (95.56%) followed by emamectin benzoate (91.13%) was found to be superior in controlling the semilooper. The next best treatments observed were rynaxypyr(86.69%), flubendiamide (83.47%), chlorpyriphos (80.04%) and novaluron (80.04%). Among other treatments bifenthrin (76.61%) and diafenthiuron (74.59%) were found to be moderately effective. The lower per cent of reduction of semilooper over untreated control was recorded as 57.46, 53.02 and 50.80 by monocrotophos, imidacloprid and dimethoate, respectively.

AFTER SECOND SPRAYING

Shoot and Capsule Borer (Conogethespunctiferalis)

Three Days after Spraying

Among all the treatments chlorfenapyr recorded the highest (49.69) % reduction of shoot and capsule borer over control. The next best treatments were observed to be flubendiamide (47.99%), emamectin benzoate (47.11%) and monocrotophos (44.34%). The treatments were found to be moderately effective in reducing the capsule infestation. The less effective treatments were observed to be dimethoate (13.58%), diafenthiuron (12.11%) and imidacloprid (11.88%).bifenthrin (35.54%), rynaxypyr (32.85%), chlorpyriphos (24.17%) and novaluron (22.47%) bifenthrin (47.59%), novaluron (43.92%) and chlorpyriphos (36.42%) were found to

Five Days after Spraying

Among all the treatments chlorfenapyr recorded the highest (70.42) per cent reduction of shoot and capsule borer over control. The next best treatments were observed to be flubendiamide (61.29%), emamectin benzoate (57.29%), rynaxypyr (55.45%) and monocrotophos (54.07%). The treatments may be moderately effective in reducing the capsule damage. The less effective treatments were observed to be diafenthiuron (31.60%), dimethoate (28.67%), and imidacloprid (27.41%).

Seven Days after Spraying

Seven days after treatment chlorfenapyr (75.23%) was found to be the most superior treatment against capsule borer over rest of the treatments. Among the other treatments the effective treatments were flubendiamide (69.06%), monocrotophos (63.21%), emamectin benzoate (62.40%) and rynaxypyr (60.66%). The treatments bifenthrin (51.66%), novaluron (49.21%), chlorpyriphos (44.05%) and diafenthiuron (40.43%) were found to be moderately effective in reducing the capsule damage. The low % of reduction of capsule damage over untreated control was found in imidacloprid (37.49) and dimethoate (36.95).

Tobacco Caterpillar (Spodoptera litura)

Three Days after Spraying

Among all the treatments chlorfenapyr (69%) was found to be the superior treatment against *S.litura* followed by rynaxypyr (65.16%) and emamectin benzoate (60.18%). The next best treatments were observed to be chlorpyriphos (56.56%), bifenthrin (53.39%), flubendiamide (52.71%) and novaluron (50.45%). The treatments diafenthiuron (44.80%) and imidacloprid (34.84%) were found to be moderately effective in reducing the larval population of *S.litura*. The low per cent reduction over untreated control was recorded by dimethoate (29.64) and monocrotophos (24.66).

Five Days after Spraying

Among all the treatments chlorfenapyr recorded the highest (86.71) % reduction of *S.litura* over control. The next best treatments were observed to be rynaxypyr (78.15%),emamectin benzoate (77.48%), chlorpyriphos (70.05%). The other treatments bifenthrin (65.09%), novaluron (64.19%), flubendiamide (62.61%) and diafenthiuron (62.39%) were found to be moderately effective in reducing the larval population. The low % reduction of *S.litura* over untreated control was recorded by monocrotophos (47.52), imidacloprid (45.05) and dimethoate (40.09).

Seven Days after Treatment

Seven days after treatment chlorfenapyr (95.98%) was found to be the most superior treatment against *S.litura* over rest of the treatments. Among the other treatments the effective treatments were rynaxypyr (90.40%), emamectin benzoate (88.62%) flubendiamide (86.83%). The treatments bifenthrin (79.69%), chlorpyriphos (77.01%) novaluron (71.88%) and diafenthiuron (68.75%) were found to be moderately effective in reducing the larval population. The low per cent reduction of *S.litura* over untreated control was recorded by monocrotophos (57.37), imidacloprid (55.58) and dimethoate (52.90).

Castor Semilooper (Achaea janata)

Three Days after Spraying

Among all the treatments chlorfenapyr (78.14%) followed by emamectin benzoate (47.11%) recorded the high per cent reduction of semilooper over control. The next besttreatments were observed to be rynaxypyr (65.58%), flubendiamide (64.94%) and chlorpyriphos (63.20%). The treatments novuluron (58.44%), bifenthrin (57.36%) diafenthiuron (56.71%) were found to be moderately effective in reducing the larval population. The low per cent reduction over untreated control was recorded by monocrotophos (35.28), imidacloprid (32.68) and dimethoate (30.30).

Five Days after Spraying

Emamectin benzoate (87.50%) followed by chlorfenapyr (85.78%) and rynaxypyr (83.41%) were significantly superior (85.22%) in bringing down the semilooper population over rest of the treatments. Among the other treatments the best treatments observed were flubendiamide (78.66%), chlorpyriphos (76.94%), diafenthiuron (72.63%), and novaluron (70.91%). The treatments bifenthrin (66.59%) and monocrotophos (61.85%) were found to be moderately effective in reducing the larval population of semilooper. Imidacloprid (42.67%) and dimethoate (44.18%) was found to be less effective (Table 2).

Seven Days after Treatment

Seven days after treatment chlorfenapyr (94.42%) followed by emamectin benzoate (90.56%) and flubendiamide (89.06%) were found to be superior treatments against semilooper over rest of the treatments. Among the other treatments rynaxypyr (85.84%), chlorpyriphos (83.48%), bifenthrin (82.83%) and novaluron (80.26%) were effective against semilooper. The treatments, diafenthiuron (76.18%) and monocrotophos (70.60%) were found to be moderately effective in reducing the larval population. The low per cent of reduction of semilooper population over untreated control was found in imidacloprid (62.02) and dimethoate (57.94).

The pooled data of the two sprays indicated that all the treatments were found significantly superior over untreated control in reducing pest population (Table 3). The maximum per cent reduction of capsule borer infestation over untreated control was observed in the treatment chlorfenapyr (65.11) followed by flubendiamide (59.45). These results are in conformity with the findings of Deepak andShashi (2013) who reported flubendiamide was most effective in reducing fruit and shoot borer infestation in okra. Highest control of tobacco caterpillar was observed in the plot treated with chlorfenapyr (83.99%) followed by rynaxypyr (77.41%), emamectin benzoate(74.30%) and flubendiamide(67.37%). The present results are in agreement with the findings of Sreenivaset al. (2008)and also Venkateswari et al. (2008). The pooled data (Table 3) indicates that maximum reduction of semilooper over control was observed in the treatment with chlorfenapyr (85.72%) followed by emamectin benzoate (82.51%). Lepidopteran pests were better controlled by flubendiamide, rynaxypyr and emamectin benzoate. The results are in conformity with the findings of Vinoth et al. (2007)and Nauenet al. (2007) who asserted that flubendiamide is a new chemical option for control of multi-resistant noctuid pests and an excellent choice for lepidopteran pests in general. Moderate control of the major pests was observed with the other insecticides like novaluron, diafenthiuron, chlorpyriphos, bifenthrin, and dimethoate.

CONCLUSIONS

All the insecticidal treatments showed significantly less per cent capsule damage over untreated control (36.13). The capsule damage recorded was only 12.54 inchlofenapyr treated plot followed by flubendiamide (14.60), emamectin benzoate (16.00), monocrotophos (16.62) and rynaxypyr (18.12). The other treatments in the order of per cent capsule damage were bifenthrin (19.86), novaluron (22.14),chlorpyriphos (23.48), diafenthiuron (25.93),dimethoate (26.53) and imidacloprid(26.82).

Highest cost benefit ratio of 1: 24.63 was obtained with monocrotophos treatment followed by emamectin benzoate (1:16.75) and chlorfenapyr (1:16.40). The other promising treatments were dimetoate (1:14.87), bifenthrin (1:13.06), imidacloprid (1:13.53) and chlorpyriphos (1:11.79). The next best treatments with cost benefit ratio were flubendiamide (1:9.97) and rynaxypyr (1:9.01). The less cost benefit ratio was obtained from the treatments, novaluron (1:4.61) and diafenthiuron (1:4.05).

The mean efficacy of all insecticides were high in second spray when compared to first spray in terms of per cent reduction over control which indicates the two sprayings were effective in controlling the insect population rather than single spray. Among the insecticides evaluated chlorfenapyr 10 SC @1.5 ml l^{-1} followed by monocrotophos 36 WSC @1.6 ml l^{-1} were found to be effective against major insect pests by recording high per cent of reduction over untreated control, higher yield and less per cent of capsule damage. Flubendiamide 480 SC @ 0.2 ml l^{-1}, emamectin benzoate 5 SG @ 0.2 g l^{-1}, and rynaxypyr 18.5 SC @ 0.3 ml l^{-1} were found to be next best treatments.

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APPENDICES

Table 1: Relative Efficacy of Different Insecticides against Major Lepidopteran Pests of Castor after First Spraying

Treatments	Mean Percent of Reduction over Control					
	Tobacco Caterpillar			Semilooper		
	3DAS	5DAS	7DAS	3DAS	5DAS	7DAS
T_1 : Chlorpyriphos 20 EC @ 2.5 ml/lit	51.95 (31.10)^{d}	66.59 (43.21)^{c}	73.93 (51.65)^{c}	65.45 (41.44)^{bcde}	75.30 (50.82)^{cde}	80.04 (56.51)^{bcde}
T_2 : Monocrotophos 36 WSC @ 1.6 ml/lit	32.68 (18.09)^{b}	42.67 (24.31)^{b}	54.91 (33.09)^{b}	30.08 (20.72)^{bc}	43.92 (25.37)^{b}	57.46 (35.17)^{b}
T_3 : Dimethoate 30 EC @ 2 lm/lit	37.66 (21.55)^{b}	49.78 (29.56)^{b}	57.48 (35.58)^{b}	25.61 (13.92)^{bcd}	39.47 (22.71)^{bcd}	50.80 (30.66)^{bc}
T_4 : Flubendiamide 480 SC @ 0.2 ml/lit	54.33 (32.71)^{d}	61.85 (38.61)^{c}	85.90 (62.89)^{cd}	59.55 (37.26)^{bcde}	71.05 (46.83)^{cde}	84.47 (61.42)^{def}
T_5 : Emamectin benzoate 5 SG @ 0.2 g/lit	56.93 (35.18)^{d}	74.35 (50.28)^{c}	88.25 (67.47)^{cd}	70.93 (46.83)^{cde}	82.19 (58.68)^{def}	91.13 (71.76)^{def}
T_6 : Rynaxypyr 18.5 SC @ 0.3 ml/lit	64.07 (40.39)^{d}	76.08 (51.37)^{c}	90.60 (70.84)^{cd}	64.02 (40.58)^{ed}	85.22 (62.47)^{ef}	86.69 (64.06)^{ef}
T_7 : Novaluron 10 EC @ 1 ml/lit	49.57 (29.56)^{cd}	59.91 (36.87)^{c}	69.23 (45.38)^{c}	57.11 (34.87)^{bcde}	70.04 (45.93)^{cde}	80.04 (56.51)^{bcd}
T_8 : Diafenthiuron 50 WP @ 1g/lit	42.42 (24.31)^{cd}	57.11 (35.18)^{c}	64.53 (40.72)^{c}	54.88 (33.31)^{bcde}	70.85 (46.83)^{cde}	74.59 (50.06)^{bc}
T_9 : Chlorfenapyr 10 SC @ 1.5 ml/lit	66.45 (43.21)^{d}	85.78 (62.68)^{c}	100.00 (99.83)^{d}	75.20 (50.82)^{e}	85.22 (62.47)^{f}	95.56 (80.09)^{f}
T_{10} : Imidacloprid 17.8 SL @ 0.3 ml/lit	27.92 (15.43)^{bc}	42.67 (24.31)^{b}	52.56 (31.48)^{b}	36.78 (20.72)^{b}	41.70 (24.04)^{bc}	53.02 (32.14)^{bc}
T_{11} : Bifenthrin 10 EC @ 1ml/lit	51.08 (30.33)^{d}	59.27 (36.87)^{c}	76.28 (51.65)^{c}	59.15 (36.43)^{bcde}	66.40 (42.30)^{cde}	76.61 (52.12)^{cde}
T_{12} : Control	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}
SEm	3.43	4.63	7.19	4.26	5.49	6.28
CD(p=0.05)	7.12	9.59	14.92	8.83	11.38	13.02

Figures in the parenthesis are angular transformed values

The values followed by same letter do not differ significantly as per DMRT.

Table 2: Relative Efficacy of Different Insecticides against Major Lepidopteran Pests of Castor after Second Spraying

Treatments	Mean Percent of Reduction Over Control								
	Capsule Borer			Tobacco Caterpillar			Semilooper		
	3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS	3 DAS	5 DAS	7 DAS
T_1 : Chlorpyriphos 20 EC @ 2.5 ml/lit	24.17 (14.46)	36.42 (22.52)	44.05 (27.87)^{c}	56.56 (34.60)^{cd}	70.05 (45.91)	77.01 (52.87)^{cdf}	63.20 (39.50)^{cd}	76.94 (52.50)^{e}	83.48 (60.12)^{cde}
T_2 : Monocrotophos 36 WSC @ 1.6 ml/lit	44.34 (27.90)	54.07 (35.01)	63.21 942.23)^{f}	24.66 (13.54)^{b}	47.52 (27.99)^{bc}	57.37 (34.97)^{b}	35.28 (20.15)^{b}	61.85 (38.61)^{c}	70.60 (46.38)^{bc}
T_3 : Dimethoate 30 EC @ 2 lm/lit	13.58 (8.04)^{b}	28.67 (17.46)	36.95 (23.02)^{b}	29.64 (16.27)^{b}	40.09 (22.63)	52.90 (31.61)^{b}	30.30 (16.80)^{b}	44.18 (25.77)^{b}	57.94 (35.54)^{b}
T_4 : Flubendiamide 480 SC @ 0.2 ml/lit	47.99 (30.51)	61.29 (40.61)	69.06 (47.37)^{g}	52.71 (32.04)^{cd}	62.61 (39.97)	86.83 (65.15)^{e}	64.94 (41.28)^{cd}	78.66 (54.85)^{e}	89.06 (67.47)^{de}
T_5 : Emamectin benzoate 5 SG @ 0.2 g/lit	47.11 (29.90)	57.29 (37.52)	62.40 (41.56)^{f}	60.18 (37.24)^{ed}	77.48 (52.60)	88.62 (66.75)^{e}	72.73 (48.14)^{cd}	87.50 (65.71)^{g}	90.56 (70.84)^{de}
T_6 : Rynaxypyr 18.5 SC @ 0.3 g/lit	32.85 (20.08)	55.45 (36.04)	60.66 (40.25)f	65.16 (41.95)^{ed}	78.15 (34.60)	90.40 (70.20)^{f}	65.58 (42.25)^{cd}	83.41 (59.89)^{f}	85.84 (62.89)^{de}
T_7 : Novaluron 10 EC @ 1 ml/lit	22.47 (13.42)	43.92 (27.60)	49.21 (31.54)d	50.45 (30.39)^{bc}	64.19 (40.96)	71.88 (47.29)^{e}	58.44 (36.03)^{c}	70.91 (47.09)^{e}	80.26 (56.31)^{cde}
T_8 : Diafenthiuron 50 WP @ 1g/lit	12.11 (7.19)^{b}	31.60 (19.25)^{b}	40.43 (25.24)^{bc}	44.80 (26.42)^{bcd}	62.39 (39.97)^{cd}	68.75 (44.17)^{bcde}	56.71 (34.33)^{c}	72.63 (48.14)^{de}	76.18 (51.65)^{cd}
T_9 : Chlorfenapyr 10 SC @ 1.5 ml/lit	49.69 (31.74)	70.42 (48.39)	75.23 (52.95)^{h}	69.00 (44.88)^{e}	86.71 (64.95)	95.98 (82.06)^{f}	78.14 (53.63)^{d}	85.78 (62.68)^{f}	94.42 (77.11)^{e}
T_{10} : Imidacloprid 17.8 SL @ 0.3 ml/lit	11.88 (7.00)^{b}	27.41 (16.60)	37.49 (23.39)^{b}	34.84 (19.78)^{bc}	45.05 (26.42)	55.58 (34.11)^{b}	32.68 (18.09)^{b}	42.67 (24.31)^{b}	62.02 (38.96)^{b}
T_{11} : Bifenthrin 10 EC @ 1ml/lit	(35.54) (21.95)	47.59 (30.14)	51.66 (33.33)^{e}	53.39 (32.87)^{cd}	65.09 (41.95)	79.69 (55.34)^{ef}	57.36 (35.18)^{c}	66.59 (43.21)^{cd}	82.83 (58.80)^{cde}
T_{12} : Control	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00	0.00^{a}	0.00^{a}	0.00^{a}
SEm±	3.14	3.81	4.06	3.75	4.71	6.35	4.44	5.49	5.94
CD	6.50	7.90	8.43	7.77	9.78	13.17	9.20	11.38	12.31

Figures in the parenthesis are angular transformed values

The values followed by same letter do not differ significantly as per DMRT

Table 3: Cumulative Efficacy of Different Insecticides against Major Lepidopteran Pests of Castor

Treatments	Mean Percent of Reduction Over Control												
	Capsule Borer				Tobacco Caterpillar				Semilooper				Yield (Kg/Ha)
	3 DAS	5 DAS	7 DAS	Mean	3 DAS	5 DAS	7 DAS	Mean	3 DAS	5 DAS	7 DAS	Mean	
T_1	24.17(14.46)^{c}	36.42 (22.52)^{b}	44.05 (27.87)^{cd}	34.88 (21.61)^{b}	54.25 (31.97)^{bc}	68.32 (43.89)^{d}	75.47 (51.95)^{de}	66.01 (42.61)^{cd}	64.33 (40.95)^{cd}	76.12 (51.24)^{cde}	81.76 (57.42)^{d}	74.07 (49.87)^{cde}	1030
T_2	44.34(27.90)^{d}	54.07 (35.01)^{b}	63.21 942.23)^{f}	53.87 (35.04)^{b}	28.67 (16.95)^{b}	45.10 (25.23)^{b}	56.14 (33.56)^{bc}	43.30 (25.25)^{b}	32.68 (20.58)^{b}	52.89 (28.68)^{b}	64.03 (37.97)^{bc}	49.87 (29.08)^{b}	1636.57
T_3	13.58 (8.04)^{b}	28.67 (17.46)^{b}	36.95 (23.02)^{b}	26.40 (16.17)^{b}	33.65 (20.23)^{b}	44.94 (27.83)^{bc}	55.19 (34.59)^{b}	44.59 (27.55)^{b}	27.96 (14.64)^{b}	41.83 (23.48)^{b}	54.37 (31.88)^{b}	41.39 (23.33)^{b}	1266.20
T4	47.99 (30.51)^{d}	61.29 (40.61)^{b}	69.06 (47.37)^{g}	59.45 (39.49)^{b}	53.52 (32.55)^{bc}	62.23 (38.95)^{cd}	86.36 (63.46)^{ef}	67.37 (44.98)^{cd}	62.24 (38.26)^{cd}	74.86 (48.84)^{cde}	86.77 (62.93)^{de}	74.62 (50.01)^{cde}	1476.85
T_5	47.11 (29.90)^{d}	57.29 (37.52)^{b}	62.40 (41.56)^{f}	55.60 (36.33)^{b}	58.55 (35.69)^{c}	75.92 (50.86)^{de}	88.43 (67.29)^{ef}	74.30 (51.28)^{de}	71.83 (47.16)^{cd}	84.84 (60.44)^{e}	90.84 (71.53)^{e}	82.51 (59.71)^{ef}	1527.77
T_6	32.85 (20.08)^{c}	55.45 (36.04)^{b}	60.66 (40.25)f	49.65 (32.12)^{b}	64.61 (40.78)^{c}	77.12 (47.18)^{de}	90.50 (70.68)^{ef}	77.41 (52.88)^{de}	64.80 (41.00)^{cd}	84.31 (61.83)^{de}	86.27 (63.77)^{de}	78.46 (55.53)^{def}	1592.59
T_7	22.47 (13.42)^{c}	43.92 (27.60)^{b}	49.21 (31.54)de	38.53 (24.18)^{b}	50.01 (29.77)^{bc}	62.05 (37.89)^{cd}	70.55 (45.86)^{cde}	60.87 (37.84)^{cd}	57.78 (35.16)^{c}	70.47 (46.22)^{cd}	80.15 (56.46)^{d}	69.47 (45.95)^{cd}	988.79
T_8	12.11 (7.19)^{b}	31.60 (19.25)^{b}	40.43 (25.24)^{bc}	28.05 (17.22)^{b}	43.61 (24.84)^{bc}	59.75 (36.38)^{cd}	66.64 (41.58)^{bcd}	56.67 (34.27)^{bc}	55.79 (33.56)^{c}	71.74 (47.16)^{cd}	75.39 (50.46)^{cd}	67.64 (43.73)^{c}	958.79
T_9	49.69 (31.74)^{d}	70.42 (48.39)^{b}	75.23 (52.95)^{h}	65.11 (44.36)^{b}	67.73 (43.63)^{c}	86.24 (63.25)^{e}	97.99 (95.39)^{f}	83.99 (67.42)^{e}	76.67 (51.52)^{cd}	85.50 (62.52)^{de}	94.99 (79.34)^{e}	85.72 (64.46)^{f}	1973.6
T_{10}	11.88 (7.00)^{b}	27.41 (16.60)^{b}	37.49 (23.39)^{b}	25.59 (15.66)^{a}	31.38 (16.52)^{b}	43.86 (24.84)^{bc}	54.07 (32.14)^{bcd}	43.10 (24.49)^{b}	34.74 (20.06)^{b}	42.19 (24.11)^{b}	57.52 (33.85)^{b}	44.81 (26.01)^{b}	1042.13
T_{11}	(35.54) (21.95)^{c}	47.59 (30.14)^{b}	51.66 (33.33)^{e}	44.93 (28.47)^{b}	52.24 (30.96)^{bc}	62.18 (38.14)^{cd}	77.98 (52.57)^{de}	64.13 (40.56)^{cd}	58.25 (36.12)^{c}	66.50 (42.53)^{c}	79.72 (53.79)^{d}	68.16 (44.16)^{c}	1250
T_{12}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	470.37
SEm±	6.50	7.90	8.43	3.62	3.49	4.58	6.95	4.96	4.30	5.46	6.17	5.28	
CD	6.50	7.90	8.43	7.51	7.25	9.50	14.42	10.29	8.91	11.32	12.80	10.94	

T_1: Chlorpyriphos 20 EC @ 2.5 ml/lit; **T_2**: Monocrotophos 36 WSC @ 1.6 ml/lit; **T_3**: Dimethoate 30 EC @ 2 lm/lit; **T_4** : Flubendiamide 480 SC @ 0.2 ml/lit; **T_5**: Emamectin benzoate 5 SG @ 0.2 g/lit; **T_6**: Rynaxypyr 18.5 SC @ 0.3 g/lit; **T_7**: Novaluron 10 EC @ 1 ml/lit; **T_8**: Diafenthiuron 50 WP @ 1g/lit; **T_9**: Chlorfenapyr 10 SC @ 1.5 ml/lit; **T_{10}**: Imidacloprid 17.8 SL @ 0.3 ml/lit; **T_{11}**: Bifenthrin 10 EC @ 1ml/lit; **T_{12}**: Control.

Table 4: Yield and Economics of Different Insecticidal Treatments Against Major Insect Pest Complex in Castor

Treatments	Per Cent Capsule Damage	Yield(Kg/Ha)	Increased Yield Over Control Kg	Additional Income Over Control (Rs.30.42 Per Kg)	Cost Of Application (Rs.Ha^{-1})	Net Profit (Rs.Ha^{-1})	ICBR
T_1 : Chlorpyriphos 20 EC @ 2.5 Ml/Lit	**23.48(28.93)**	**1030**	**559.63**	**17023.94**	**1331.25**	**15692.69**	**1:11.79**
T_2 : Monocrotophos 36 WSC @ 1.6 ml/lit	16.62 (24.04)	1636.57	1166.2	35475.80	1384.00	34091.8	1:24.63
T_3 : Dimethoate 30 EC @ 2 lm/lit	26.53 (30.98)	1266.2	795.83	24209.15	1525.00	22684.15	1:14.87
T_4 : Flubendiamide 480 SC @ 0.2 ml/lit	14.60 (22.46)	1476.85	1006.48	30617.12	2790.00	27827.12	1:09.97
T_5 : Emamectin benzoate 5 SG @ 0.2 g/lit	16.00 (23.58)	1527.77	1057.4	32166.11	1812.00	30354.11	1:16.75
T_6 : Rynaxypyr 18.5 SC @ 0.3 ml/lit	18.12 (25.18)	1592.59	1122.22	34137.93	3410.00	30727.93	1:09.01
T_7 : Novaluron 10 EC @ 1 ml/lit	22.14 (28.04)	988.79	518.42	15770.34	2810.00	12960.34	1:04.61
T_8 : Diafenthiuron 50 WP @ 1g/lit	25.93 (30.59)	958.79	488.42	14857.74	2940.00	11917.74	1:04.05
T_9 : Chlorfenapyr 10 SC @ 1.5 ml/lit	12.54 (20.70)	1973.6	1503.23	45728.26	2627.50	43100.76	1:16.40
T_{10} : Imidacloprid 17.8 SL @ 0.3 ml/lit	26.82 (31.18)	1042.13	571.76	17392.94	1237.00	16155.94	1:13.06
T_{11} : Bifenthrin 10 EC @ 1ml/lit	19.86 (26.42)	1250	779.63	23716.34	1632.00	22084.34	1:13.53
T_{12} : Control	36.13 (36.93)	470.37					
S.Em±	1.33						
CD @ 0.05 level	2.75						